DEVELOPMENT OF THE SMALL SCALE PISTON TYPE BRIQUETTING TOOL

MOHAMMAD KHAIRULNIZAM BIN IBRAHIM

Thesis submitted to the Faculty of Mechanical Engineering in
Partial Fulfillment of the requirement for the award of the degree of
Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering

UNIVERSITI MALAYSIA PAHANG

JUNE 2013

ABSTRACT

Currently, renewable energy is becoming an important source of energy in our world. Renewable energy is a solution that can overcome the problems that occur in our world right now such as global warming, urban smog, acid rain and many more dangerous emmisions. Biomass is one the sources of renewable energy that have specific properties that can change our world environment right now. Biomass use and application is the one way for decreasing the above negative effect to the world. Briquette technology is the one technology which uses the biomass product in the right way. In order to develop a small scale of piston type briquetting tools, an analysis was carried out to choose the best design to develop briquette machine. Four samples of different designs then was sketch in 3D drawing by using Solidworks Premium Software. Every designs was sketch in different application of theories which are pascal theory, bottle jack theory, bottle jack theory with heavy duty spring and use of power supply of motor. By using Solidwork Premium Software stress strain anlysis, the designs then being analysed. After do the analysis, comparison and concept selection between the designs was carried out. The result is finalised and the concept of using of power supply of motor is selected. For the final stage, the machine was fabricate by using the selected concept.

ABSTRAK

Pada masa ini, tenaga boleh diperbaharui menjadi sumber tenaga yang terkenal di dunia kita. Tenaga boleh diperbaharui diketahui bahawa boleh mengatasi masalah yang berlaku dalam dunia kita sekarang seperti pemanasan global, kabus bandar, hujan asid dan banyak lagi pelepasan asap yang lebih berbahaya. Biomas adalah salah satu sumber tenaga boleh diperbaharui yang mempunyai ciri-ciri tertentu yang yang boleh mengubah persekitaran dunia kita sekarang. Penerapan penggunaan biomas adalah cara yang ideal untuk mengurangkan kesan bahaya kepada dunia. Teknologi briket adalah teknologi satu yang menggunakan produk biomas ke arah cara yang betul. Untuk penghasilan mereka bentuk mesin briket jenis omboh yang berskala kecil , analisis dijalankan untuk memilih reka bentuk yang sesuai. Empat jenis dengan perbezaan reka bentuk dilakarkan dalam bentuk 3D dengan menggunakan perisian jenis Solidwork Premium. Setiap reka bentuk dilakarkan dengan menggunaka teori yang berbeza terdiri daripada teori pascal, teori jack botol, teori jack botol dengan spring tahan kuat dan penggunaan kuasa motor. Dengan menggunakan perisian Solidwork Premium, setiap reka bentuk dianalisis dengan menggunakan ujian tekanan analisis ketegangan.Selepas melakukan analisis, perbandingan dan konsep pemilihan antara reka bentuk dijalankan. Keputusan pemilihan reka bentuk dimuktamadkan dan konsep dipilih. Untuk peringkat akhir, mesin di buat dan direka dengan menggunakan konsep penggunaan bekalan kuasa motor.

TABLE OF CONTENTS

CHAPTER 5 CONCLUSION AND RECOMMENDATION

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND STUDY

Renewable energy is getting more important nowadays. Generated energy from variety of sources makes it important. There are many forms of sources that can become renewable energy and biomass is one of it. All earth's living matter thing that growth through photosynthesis which includes microbes, animal, plants and the organic material that is excreted and metabolized by them is referred as biomass (Zhang et al, 2009).

Organic matter that derived from plants is defined as biomass. Plant, animal materials such as wood from forests, seaweed, crops, material left over from agricultural and forestry processes, organic industrial, human and animal waste are the example of biomass product. Other than that, biomass also known as plant biomass or phytomass, animal biomass or zoomass. The process of converted photosynthesis into chemical energy is then stored in the form of aquatic vegetation and terrestrial after the sun's energy intercepted by plants. Zoomass (animal biomass) and excreta is converted from vegetation which is gazed by animal. The dairy terrestrial animal excreta can be used as a source of energy compared to aquatic animals, which os its excreta gets dispersed and it could not possible to collect and use for the energy production (Zhang et al, 2009).

Other than that, the earliest sources of energy in rural areas where at there often only accessible and affordable sources is biomass. Biomass as a renewable energy which have very specific properties is made up from carbohydrates. Other renewable

energy such as wind energy cannot beat biomass energy because biomass is well known as a versatile fuel that can produce liquid fuels, biogas and electricity (Saidur et al, 2011).

1.2 PROBLEM STATEMENT

As we all know, oil, coal and natural gases represent as the prime energy sources in the world. We can see that there increasing of greenhouse effect which is affected to global environment warming. Although there are prime energy sources, they gives a bad effect to the world from the production of emissions such as increasing of greenhouse effect due to global environment warming, acid rain and urban smoke and this problems have temped the world which try to reduce carbon emissions by 80% (Saidur et al, 2011).

In some places, they do the direct burning of loose biomass. They do not reuse the biomass into the correct way. Millions of tons of a biomass product, rice straws are burnt away and abandoned by the farmers in the fields after finished harvest the rice. The burning of the rice straws not only gives the pollution to the environment but also cause the traffic accident if the field is close to the freeway. When there are rainy season, the abandoned of biomass, rice straws in the field will flow into the drainage system and cause an obstruction and for sure also will provide the place for bacteria to propagate (Chuen et al, 2008).

So, the developing of biomass briquette machine is will overcome the problems to become more worst. The product that forms is called briquettes have a lot of advantages which will not emit fly ash, smoke with sulphur or phosphorus. Thus, it is not dangerous to the environment (Grover & Mishra, 1996).

1.3 PROJECT OBJECTIVES

Basically, this thesis would be done for fulfill the following

a. To design and analysis the small scale piston type briquetting tool
b. To fabricate a briquetting machine prototype of small scale piston type briquetting tool

1.4 SCOPE OF STUDY

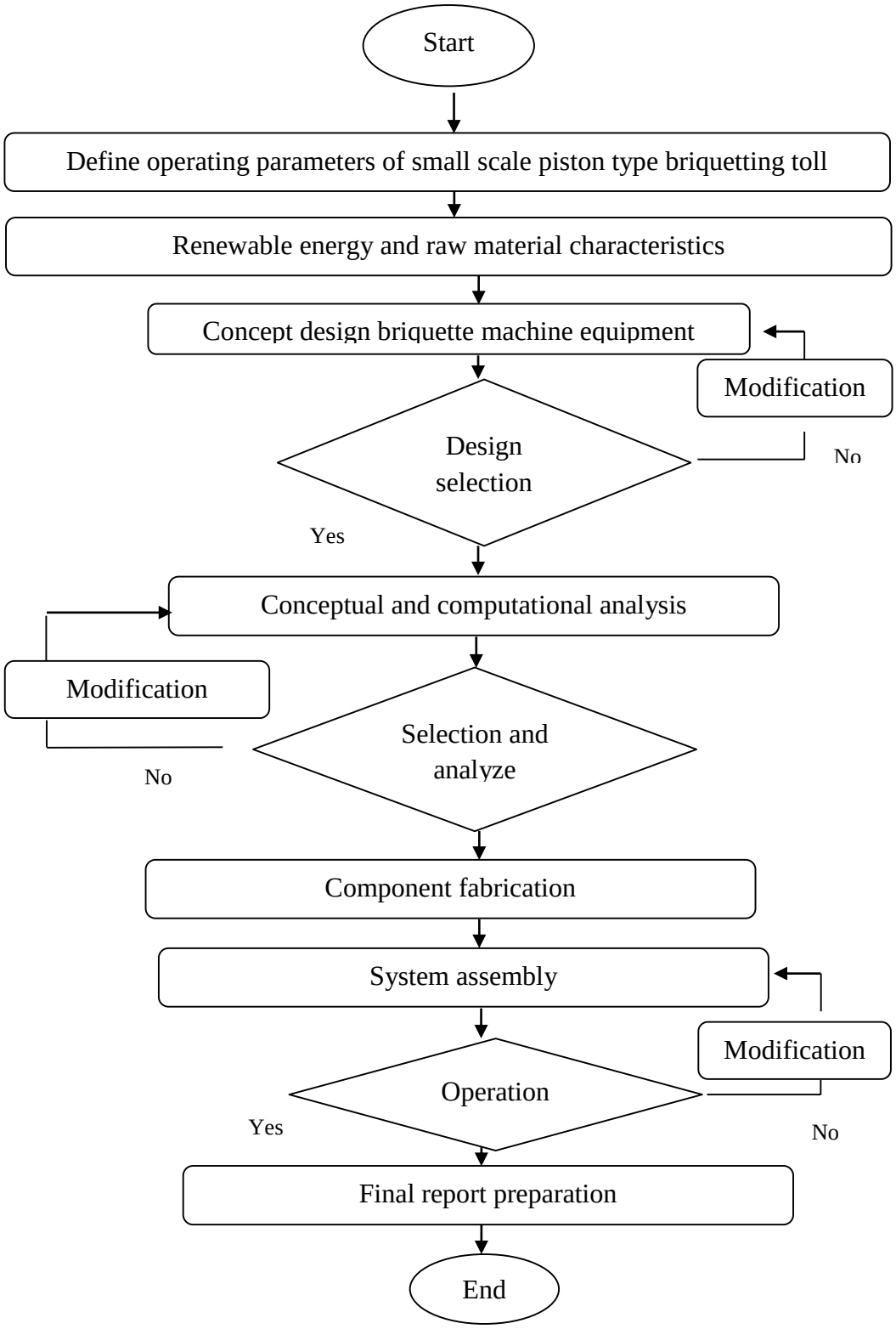
The ability to contribute the scope in designing the product is important to make it success. It can be the benchmarking for the development of the product. To accomplish the objectives, there are the scopes, which are:

a. Literature study of the small scale piston type briquetting tools using solid works.
b. Conceptual design of the small scale piston type briquetting tools.
c. Development and fabricating model of small scale piston type briquetting tool.
d. Computational analysis on the fabrication model.
e. Final report preparation

1.5 HYPOTHESIS

Briquette machine of small scale piston could achieve all aspects in design consideration which is functionality and ability of the machine. A selected design from several design will choose and by the end of the development, prototype model could mount all components together and built as working model prototyping.

1.6 FLOW CHART



CHAPTER 2

LITERATURE REVIEW

2.1 BRIQUETTE APPLICATION IN BIOMASS

Among the energy resources, biomass briquette becomes the most important energy sources. This due to biomass briquette which has variety of appealing properties such as low acidic gas emissions, low greenhouse gas and low production cost (Chuen et al, 2009).

Biomass is the third largest primary energy and then followed by coal and oil. For more than half of the world's population, biomass remains the primary source of energy. Biomass has provides about 14% of the world's annual energy consumption or 1250 million tons oil equivalent (Mtoe) to the world. If compared to fossil fuels, biomass is more better due to biomass is a renewable and sustainable fuel that can deliver significant in net of carbon emissions. Biomass also known as attractive clean development mechanism because of its function that could reducing greenhouse gas emission (Chen et al, 2009).

Biomass is an energy sources that can be classified as a combustible materials and sources for biomass are unlimited. The energy that contained in biomass actually comes from the sun. Carbon dioxide in the air is transformed into a carbon that containing molecules such as sugar in plants through photosynthesis process. These sugars are called bio-energy or known as carbohydrates are stored in plants and animals waste product (Saidur et al, 2011). Figure 2.1 shows the sources energy of biomass.

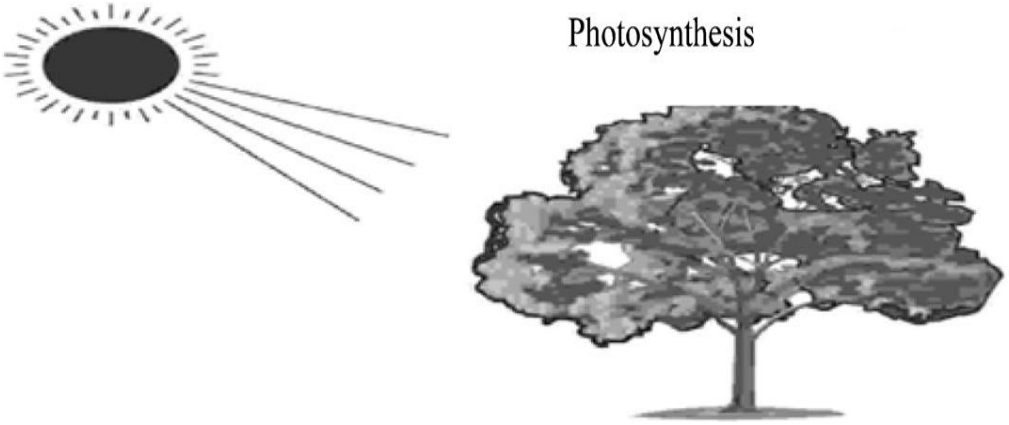


Figure 2.1 Source energy in biomass

In the photosynthesis process, radiant energy is converted from plants to the sun into chemical energy in the form of glucose:

Water + Carbon dioxide + Sunlight $\longrightarrow$ Glucose + Oxygen

$6H_20 + 6CO_2$ + Radiant Energy $\longrightarrow$ $C_6H_{12}0 + 60_2$

Source: Saidur et al (2011)

Currently, fossil fuel such as coal, oil and natural gas has becomes the primary energy in the world. Although fossil fuel got the highest ranking, however it is anticipated that it will depleted within in the next 40-50 years. So, biomass is the best sources to replace fossil fuels. Biomass is the better sources compared to fossil fuels which will make the environmental damages such as acid rain, dangerous smoke, acid rain and others problems that can caused an increasing in carbon emissions (Saidur et al, 2011). Table 2.1 and Figure 2.2 shows the target of biomass sources for future.

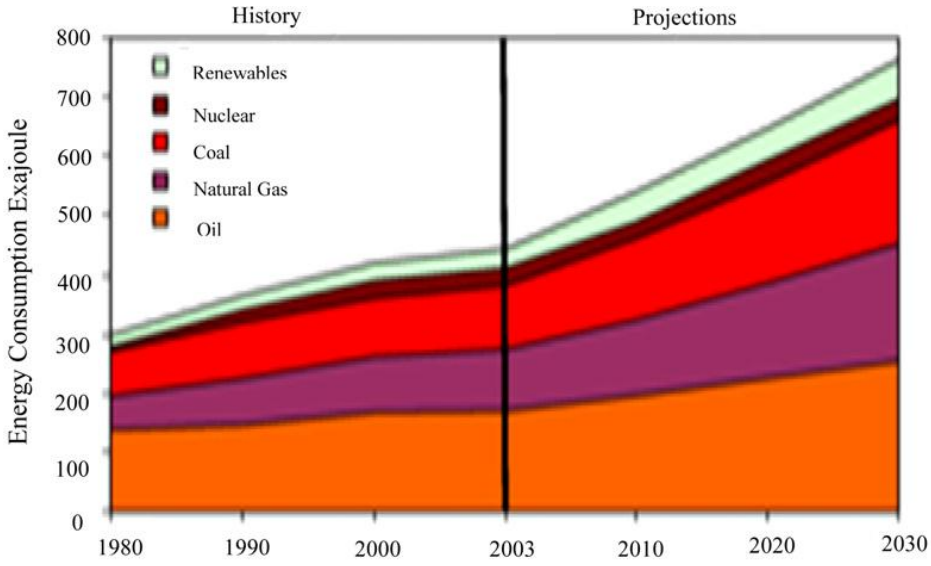


Table 2.1 Energy Consumption

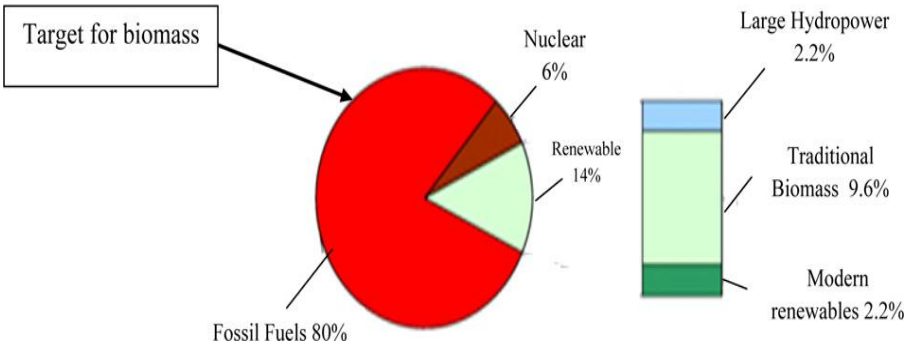


Figure 2.2 Sources of energy consumption

Sources: Saidur et al (2011)

Biomass also known as carbon neutral source of energy which means when biomass in burned or used it after converting it to other types of fuel like liquid, solid, and gaseous fuels (charcoal, ethanol, methane), the biomass carbon then reacts with oxygen to form carbon dioxide . This carbon dioxide will be released to the atmosphere. The amount of carbon dioxide which is fully combusted is equal to the amount which was taken from during the growing stage from the atmosphere. So, biomass can be regarded as a carbon sink as there is no addition of carbon dioxide. This process is known as zero carbon emissions or a carbon cycle (Saidur et al, 2011). Figure 2.3 shows flow of a carbon cycle.

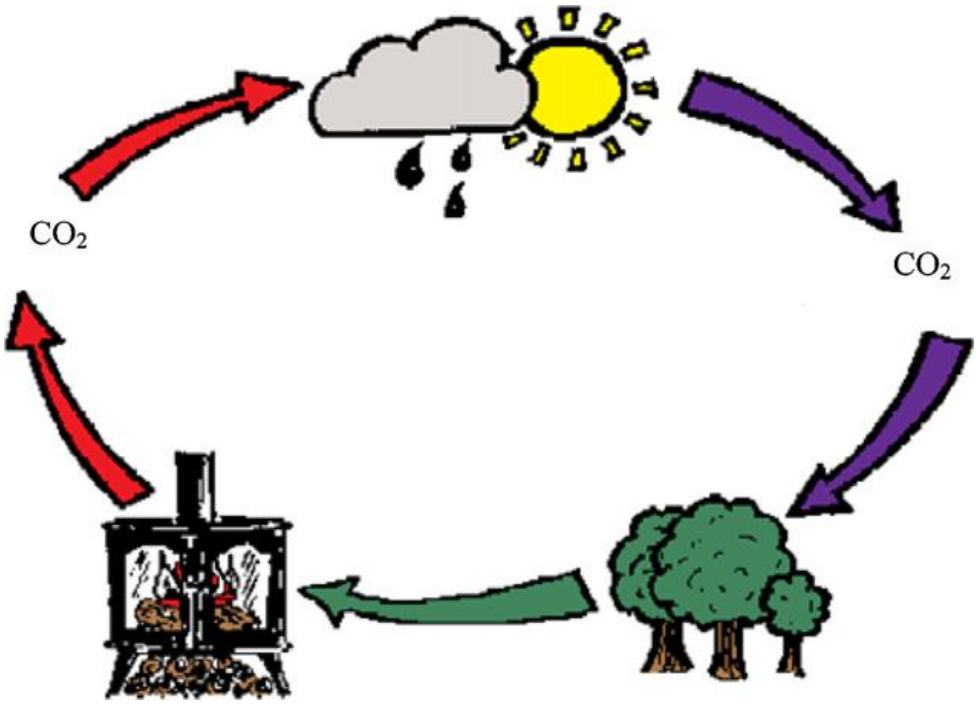


Figure 2.3 Carbon Cycle of Biomass Product

Sources: Saidur et al (2011)

One of the technologies which convert loose agricultural residues or biomass product is develop which is biomass briquetting (Chen et al, 2009). Biomass briquetting is the process known as biomass densification which represents a technology set that makes a fuel by conversion of biomass. Energy production can be expanding by using this biomass technology. For the compaction technique, the solid particles are the starting of the material (Grover & Mishra, 1996).

Briquette technology is the process where giving a high pressure to the raw materials and then then raw materials will become in a compact shape. The strength of the compact shape of solid is affected by Van der Waal's forces, valence electron or interlocking. A binder between the particles will forms due to prevailing a high pressure condition to the raw material (Grover & Mishra, 1996). The figure 2.4 shows some of the mechanism binding.

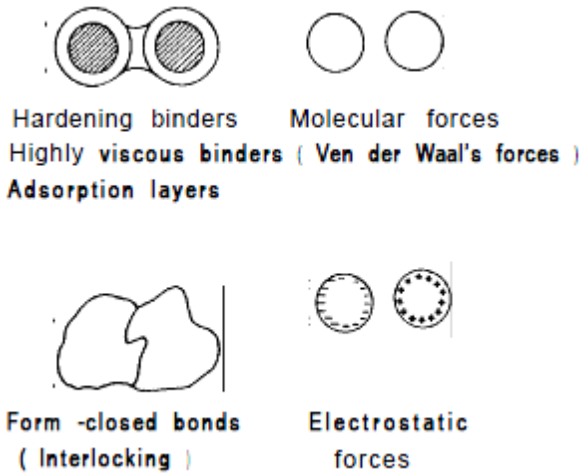


Figure 2.4 Binding mechanism in biomass product

Sources: Grover & Mishra (1996)

2.2 PARAMETERS THAT INFLUENCED PROCESS OF THE BRIQUETTE

To achieve a good quality of briquette, there are some parameters need to follow. A parameters need to be review to get a good quality of briquette.

2.2.1 Moisture Content

The moisture content is one of the critical factors that influence strengthens of the briquette. At 6-8 percent of moisture content, the briquette will in a strong condition and free of cracks. When the moisture content more than 10%, the briquette condition is in poor and week and the briquette operation also will be in erratic. Water also acts as a binder agent. Water helps to promote the bonding of van der WaAls' by increasing the area of contact of the particles (Grover & Mishra, 1996).

The moisture content should be the range of 10-15%. High moisture content will pose a problem due to excessive energy required for drying and firing. Huge moisture will lead to hinder the combustion of reaction products, reduces the combustion temperature and most worst is it will affect the quality of the combustion (Chen et. al, 2009). Low moisture content is the most important factor to increase the strength (Chou

et al, 2009). Table 2.2 shows different biomass materials have the different moisture content.

Table 2.2 Sample of biomass moisture content

Crop	**Residue**	**Moisture Content (%)**
Rice	Straw	15.5
Rice	Husk	10.4
Corn	Stalk	7.7
Corn	Cob	11.0
Corn	Husk	14.6
Wheat	Straw	15.0
Millet/Rye/Oats	Straw	16.3
Barley	Straw	15.0
Sorghum	Straw	15.0
Cassava	Stalk	7.8
Groundnut	Husk/Shell	12.0
Groundnut	Straw	15.0
Soybean	Straw	49.8
Sugar cane	Bagasse	62.5
Sugar cane	Tops/Leaves	12.0
Cotton	Stalk	10.0
Cotton	Husk	10.0
Coconut	Shell	10.9
Oil palm	Shell	7.3
Oil palm	Fibre	36.7
Oil palm	Empty bunches	36.7
Coffee	Husk	15.0

Source: Chen et al (2009)

2.2.2 Particle size

Size of particle and shape are the main important factor to produce briquette. There are a lot of sizes that can be made but the ideal size is the particle size between 6-8 mm with 10-20% powdery component is the best result. The size of the material will affect the appearance the briquette. When use 10-5 mm size of particle, the appearance of solid briquette is rougher than compared by using 5- 2 mm size of particle (Chou et al, 2009).

High static strength and appearance will depends on the present of different size of particles. The machine will be jammed and the briquetting process will not be smooth and clogging will occur if using briquette material of oversized particles (Mazzu, 2007). Table 2.3 shows the appearance of compactness of biomass briquette due to use variety of size.

Table 2.3 Appearance compactness of briquette

Test	**Material**	**Particle Size (mm)**	**Maximum pressure (bar)**	**Density (g/cm^3)**	**Apparent compactness**
1	Straw	30-50	300	0.57	Insufficient
2	Straw	30-50	400	0.57	Medium
3	Straw	30-50	580	0.74	Good
4	Straw	30-50	400	0.61	Sufficient
5	Straw	10-30	580	0.80	Good
6	Straw	10-30	580	0.84	Good
7	Straw	10-30	580	0.85	Good
8	Millet stems	10-15	580	0.83	Good
9	Millet stems	10-15	580	0.92	Good
10	Millet stems	10-15	580	0.88	Good
11	Grass	10-15	580	1.01	Good
12	Grass	10-15	580	1.06	Good
13	Grass	10-15	580	1.01	Good
14	Grass/stems/straw/leaves	10-15	580	0.84	Good

Source: Mazzu (2007)

2.2.3 Temperature

Briquette crushing strength and moisture stability can be varied by varying the temperature of biomass of the briquette density. In a screw extruder cases, the external and internal friction causes local heating and self-bonding material properties is develop at elevated temperature (Grover & Mishra, 1996).

Moisture present in the material forms can be assumed to form steam at high pressure conditions which then hydrolyses the hemicellulose and lignin portions of biomass into lower lignin products, sugar polymers, molecular carbohydrates and other derivatives. These products will act as adhesive binders and provide a bonding effect when subjected to heat and pressure. The addition of heat relaxes the inherent fibers in biomass and also softens the structure. Next, it will reduce the resistance to briquette by decreasing the specific power consumption, increasing in production rate and reduction in wear of the contact parts. The temperature also needs to not exceed the limit of 300 ^{o}C of the decomposition of temperature to avoid the circumstances (Grover & Mishra, 1996).

Table 2.4 shows the sample of test conditions of preparing the biomass briquette by use variety of temperatures.

Table 2.4 Variety of temperature used to prepare briquette

Briquette test	Percentage or rice straw/ percentage of rice bran	Size of smashed rice straw (mm)	Air-dry mass of material for preparing solid fuel (g)	Hot-pressing temperature (°c)
B 1	100/0	10-5	53.38	90
B 2	100/0	10-5	53.38	110
B 3	100/0	10-5	53.38	130
B 4	100/0	10-5	53.38	150
B 5	100/0	5-2	53.33	90
B 6	100/0	5-2	53.33	110
B 7	100/0	5-2	53.33	130
B 8	100/0	5-2	53.33	150
B 9	100/0	<2	53.58	-
B 10	100/0	<2	53.58	90
B 11	100/0	<2	53.58	110
B 12	100/0	<2	53.58	130
B 13	100/0	<2	53.58	150
B 14	80/20	<2	53.58	-
B 15	80/20	<2	53.58	90
B 16	80/20	<2	53.58	110
B 17	80/20	<2	53.58	130
B 18	80/20	<2	53.58	150
B 19	60/40	<2	53.56	-
B 20	60/40	<2	53.56	90
B 21	60/40	<2	53.56	110
B 22	60/40	<2	53.56	130
B 23	60/40	<2	53.56	150

Source: Chou et al (2009)

2.3 HISTORICAL AND DEVELOPMENT OF BRIQUETTE MACHINE

Research and developing the biomass briquette technology is expandable through the years and several technology of briquetting machine is developed. For the development of machine, there have four development of briquette machine which is hydraulic press, piston press, screw press and roller press.

2.3.1 Historical of biomass briquetting technology

The starting of developing the briquette machine still in research but it was found that the R&D (Research and Development) of biomass briquetting technology can be traced back to around 20 years ago. Institute of Chemical Industry of Forest Products (ICIFP) had carried out a research on biomass briquetting technology during China's Seventh Five-Year Plan (1986-1990). The R&D of biomass briquette technology in China is divided into three stages consists of before 1995, focusing on the basic of the technology development. The first generation technology, implement to promote the small scale industry was in year 1995 until 2005. The biomass briquetting technology improved and upgrades to achieve the vision to enter a large scale industry (Chen et al, 2009).

In pre-2005, some institutions in China has come out with develop a few prototype, such as ZT-63 biomass briquetting device (food processing machine) and OBM-88 briquette device for formed solid biofuel. In year 1996-2005, there scope more detail by study the mechanical behavior at all stages of the compression process of different biomass materials (Chen et al, 2009).

In post 2005, the scope cover on renewable and clean energy is the choice for sustainable economic growth, for the harmonious of human and environment as well as for the sustainable development. In order to ensure the rapid and promote, effective and sustainable development of biomass, the study more concerned to explore the binding mechanism, the effect of pre-processing on biomass properties, develop briquette device with high productivity and low energy consumption. The R&D aim to focus on the upgrading the briquette machine and to provide clean and renewable energy (Chen et al, 2009).